

AksIM-4™ Dual Concentric

Off-Axis Rotary Absolute Magnetic Encoder

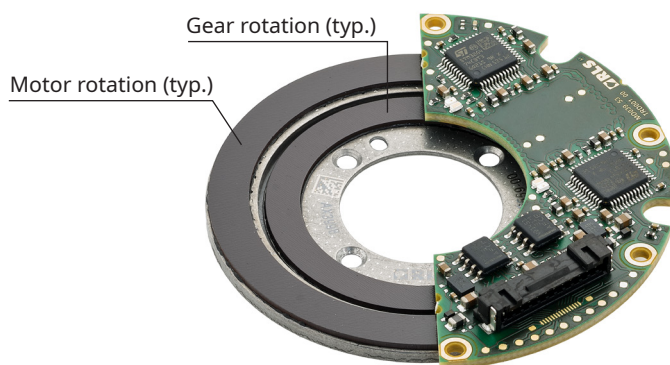
2 IN 1
POSITION
FEEDBACK

HIGH
ACCURACY &
REPEATABILITY

IDEAL FOR
HUMANOIDS

The AksIM-4 Dual Concentric high-performance encoder integrates two non-contact, absolute rotary sensors into a single device. This innovative solution provides simultaneous motor and reducer position feedback in a robot joint, enabling exceptionally smooth, synchronised and accurate motion control.

Its compact, space-saving design makes it suitable for advanced robotics and other applications with limited installation space, while maintaining high accuracy, reliability, and performance.



The image does not represent all variants.

Features and benefits

- ▶ Two-in-one encoder solution
- ▶ Ultra-compact, low-profile design
- ▶ Locking & board-to-board connector options
- ▶ Reliable plug and play solution
- ▶ Immunity to external magnetic fields
- ▶ Saves space
- ▶ Reduces complexity in robotic joints
- ▶ Immediate feedback at power-up
- ▶ Reliable performance in demanding environments



HUMANOID ROBOTS



COLLABORATIVE &
INDUSTRIAL ROBOTS



SURGICAL ROBOTS



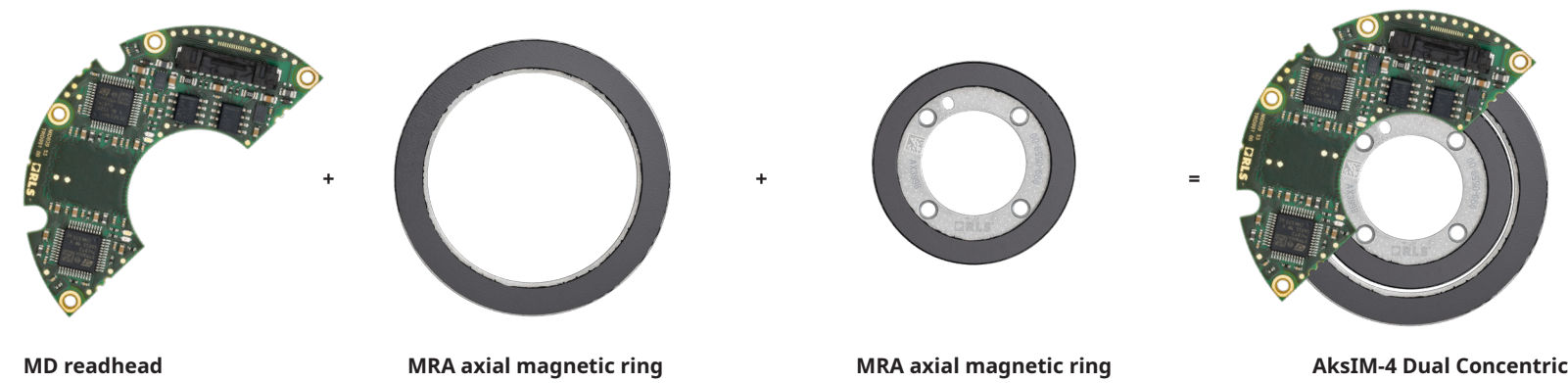
EXOSKELETONS



AVIATION

General information

The AksIM-4 Dual Concentric high-performance encoder integrates two non-contact, absolute rotary sensors in a single device. This innovative solution provides simultaneous motor and reducer position feedback in a robot joint, for exceptionally smooth, synchronised and accurate motion control. Its compact, space-saving design, makes it perfect for advanced robotics and other applications where installation space is limited – without sacrificing accuracy, reliability, or performance.



Selection guide	Magnetic ring					Readhead					
Part number	Inner diameter	Circle for fasteners	Outer diameter	Thickness	Inertia (kg × mm²)	Inner diameter	Circle for fasteners	Outer diameter	Arc length	System thickness (Typ.)	Mass (g)
MD053 assembly											
MD053						25	58	62	180°	8.45 or 9.25	5.7
MRA039	20	25	39	1.6	1.6						6.38
MRA053	40	N/A	53	2.8	9.3						16.45

All dimensions in mm.

Storage and handling

Operating and storage temperature

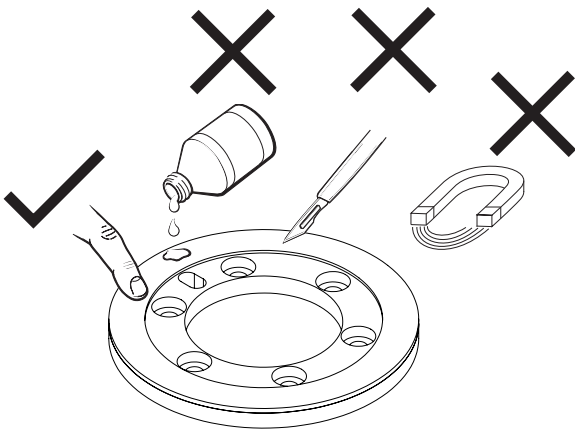


-40 °C to +105 °C

Humidity



Up to 70 % non-condensing



HANDLE WITH CARE. This encoder system is a high performance metrology product and should be treated with the same care as any other precision instrument. Use of heavy duty industrial tools or exposure to strong magnets, such as a magnetic base, is unacceptable and risks of irreparable damage to the product.

The magnetic ring should not be exposed to magnetic field densities higher than 50 mT on its surface, as this can damage the ring.

Please see [Chemical resistance](#) or [contact RLS](#).



Readhead is ESD sensitive - handle with care.

Do not touch electronic circuit, wires or sensor area without proper ESD protection or outside of ESD controlled environment.

Technical specifications

System data

Reading type	Axial reading
Maximum speed	Both rings: 7,500 rpm
Hysteresis	Less than unit of resolution
Repeatability	Within the range of position noise
Encoder speed	12.5 kHz bandwidth, 25 kHz sampling rate, up to 44 kHz refresh rate
Thermal drift	None (accuracy does not change with temperature)

Resolution	039	053
Binary	19 bit per revolution	19 bit per revolution

Accuracy	039	053
System accuracy*	±0.015°	±0.010°
Typical installed accuracy	Calibrated	±0.015°
	Uncalibrated	±0.040°

Total installed accuracy without calibration is influenced by mounting precision (e.g. eccentricity and bearing wander).

* System accuracy = Max. achievable accuracy when using self-calibration

Accurate centering of the ring is key to good overall accuracy. Minimising the eccentricity of the ring assembly (using a gauge) and using a drive shaft with precision bearings can usually reduce the error. To improve accuracy after installation, we recommend performing self-calibration.

Electrical data

Supply voltage (V_{in})	4.5 V to 5.5 V at the connector
Set-up time	100 ms (first data ready after supply voltage is in range), worst case: 200 ms
Current consumption	Typ. 250 mA, max. 320 mA (without load on the outputs)
Connection	12-pin low-profile connector or board-to-board connector
Output load	RS422: ±40 mA
ESD protection	HBM, Class 2, ±2 kV (valid only on RS422 signals on connector; do not touch other components)

Mechanical data

Ring material type	EN 1.4016 / AISI430 with glued CPE rubber filled with ferrite particles
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Environmental and operational conditions

Environmental data

Operating and storage temperature	–40 °C to +105 °C
Humidity	Up to 70 % non-condensing (for higher with conformal coating contact RLS)
External magnetic field	±15 mT
Shock	100 g (6 ms, half-sine, EN 60068-2-27:2009)
Vibration	80 g (55 Hz - 2000 Hz, EN 60068-2-6:2008)
Environmental compliance	RoHS, REACH

Chemical resistance

RLS products are commonly used in industrial applications and are exposed to chemicals that can affect their internal and external components. Although our products are designed to withstand many harsh chemicals and environments, long-term resistance depends on exposure, temperature and concentration. Most of the chemicals to which our products are exposed are not in constant contact. Therefore, a material that is not resistant when immersed in a chemical may be durable indefinitely if wiped with the same chemical once a day.

CPE rubber on the ring will not withstand exposure to most mineral oils and greases.

External magnetic field

Magnetic encoders operate by detecting changes in the magnetic field of a magnetised ring. In typical applications, nearby magnetic sources such as motors do not affect performance when the encoder is properly integrated. For optimal performance, the encoder should be mounted in the following arrangement:

Motor → Ring → Readhead.

In this configuration, the ring naturally acts as a shield between the motor and the readhead, reducing the influence of stray magnetic fields. In most applications, no additional shielding is required. If unusually strong magnetic fields are present, simple shielding—such as a thin ferromagnetic plate—can be placed between the source and the readhead.

During handling and storage, avoid placing strong magnetic objects near the ring, as they may affect its magnetic properties. Magnetic fields above 50 mT can permanently damage the ring.

Operation in high-pressure applications

The encoder can be configured to operate at ambient pressures of up to 600 bar. Typical applications include ROV submarines where the entire system is submerged in oil.

Operation in ultra-high-vacuum applications

AksIM encoders are suitable for operation in ultra-high-vacuum environments down to 1.0×10^{-7} Pa. The encoders were tested for outgassing under ultra-high-vacuum conditions with test parameters similar to the ECSS-Q-ST-70-02C (2008) and ASTM E595-15 (2021) standards. No critical outgassing was detected. The relative mass loss (RML) of the ring and readhead were 0.01 % and 0.09 %, respectively. The ultra-high vacuum test had no effect on the performance of the encoder.

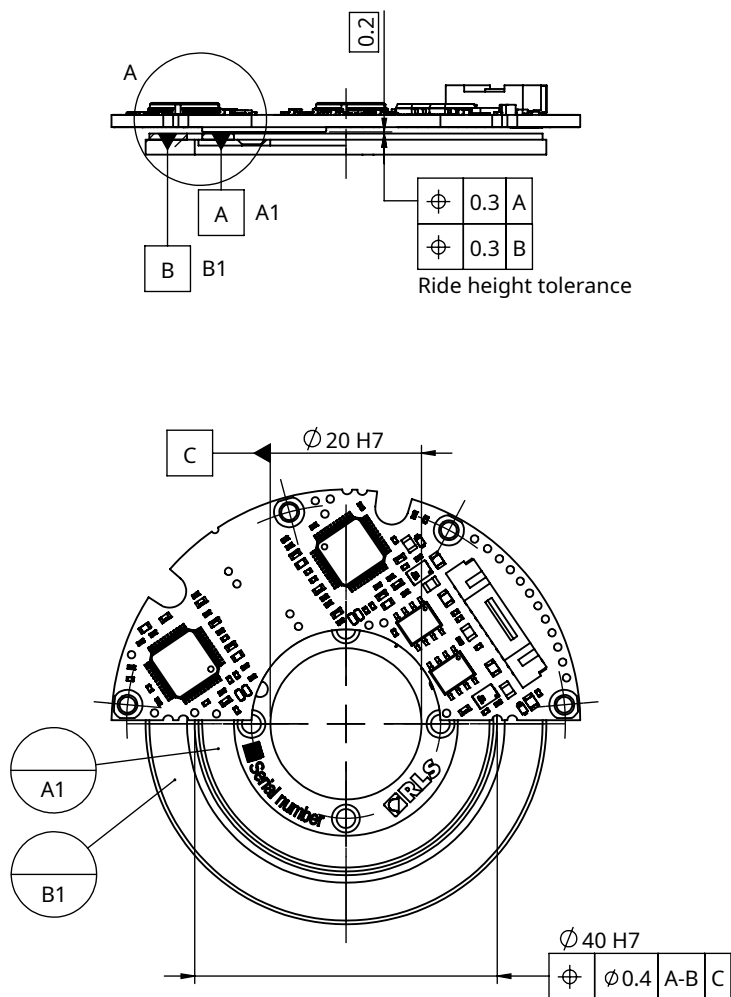
For additional details, please [contact RLS](#).

Dimension and installation drawings

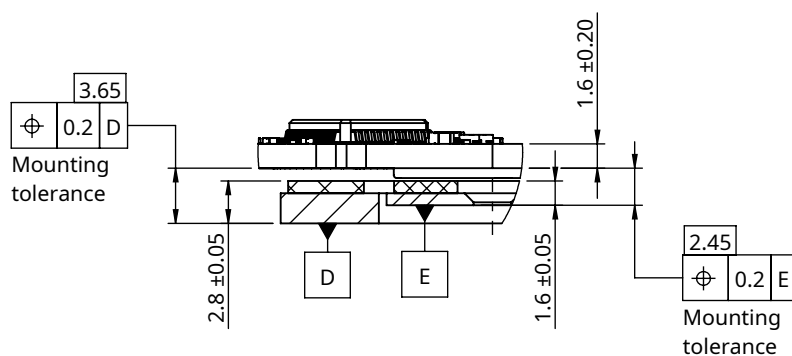
Dimensions and tolerances are in mm. Dimensions without tolerance values are in accordance with ISO 2768-m.



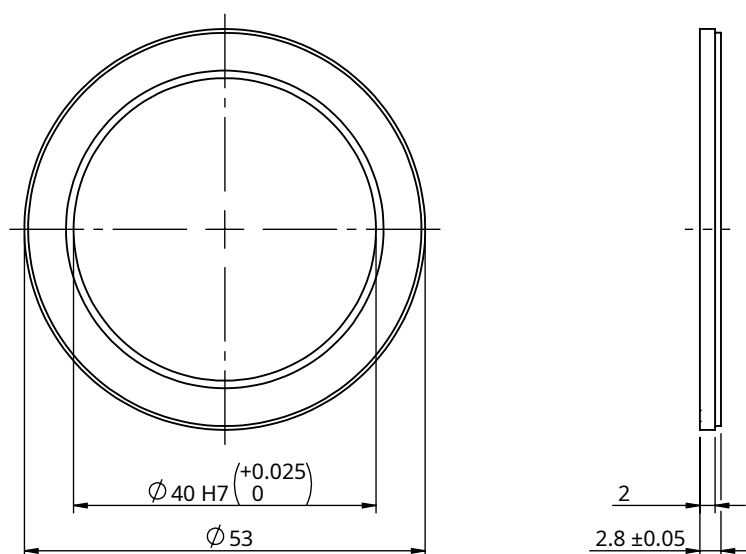
Encoder assembly MD053C readhead with MRA053 and MRA039 magnetic rings



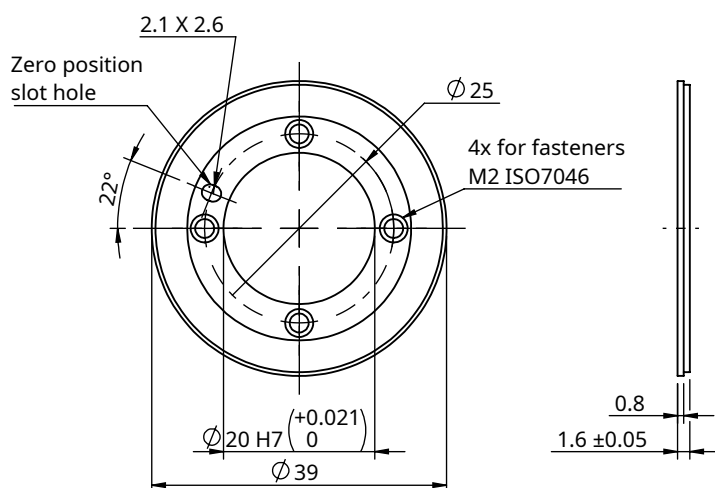
DETAIL A (2 : 1)



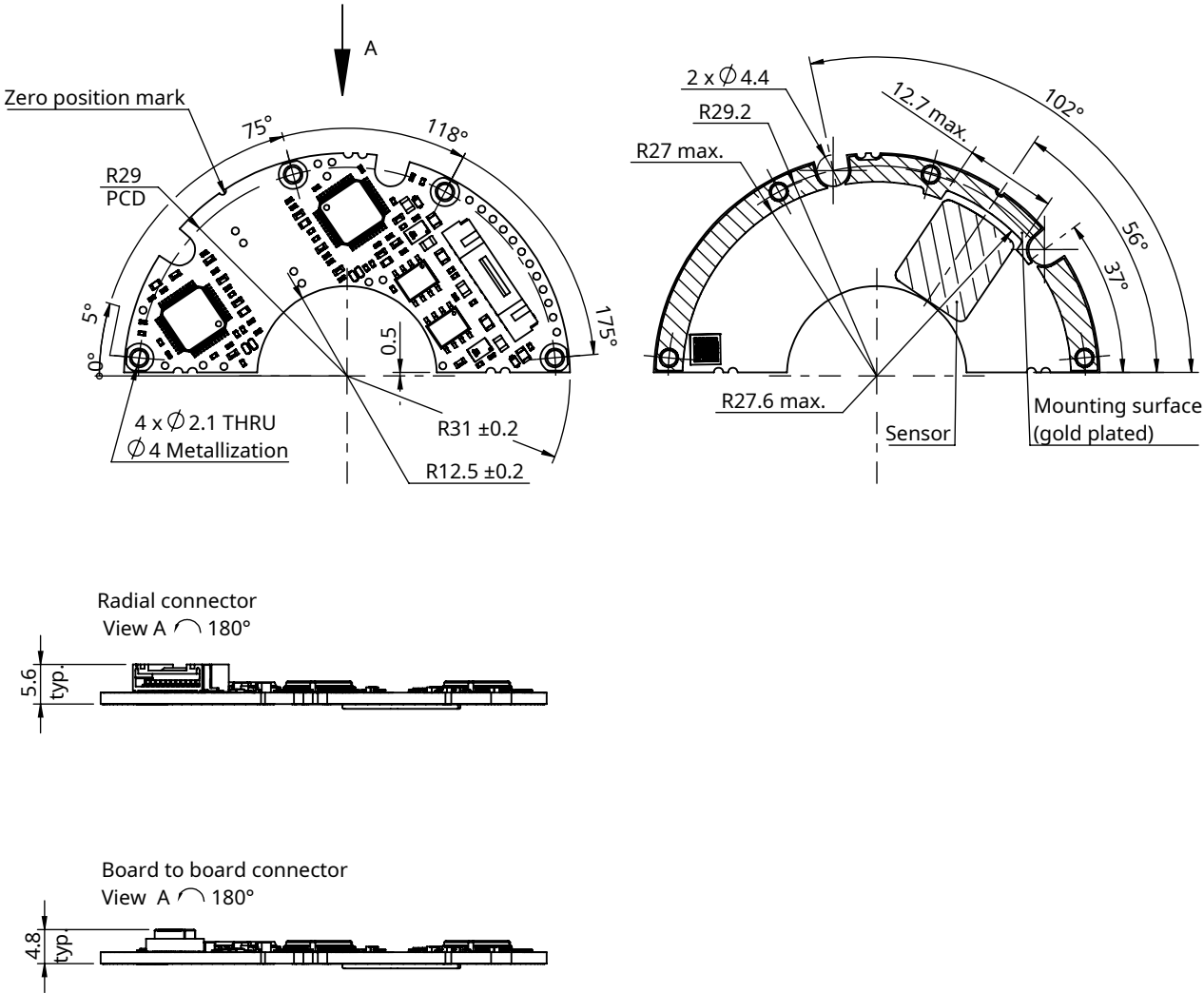
MRA053 magnetic ring



MRA039 magnetic ring



MD053C readhead



Installation instructions

Axial position adjustment (mounting distance and ride height)

 [AksIM installation video](#)

The mounting distance between the gold-plated surface at the bottom of the readhead and the bottom of the ring should be as defined on the dimension drawings of encoder assemblies. It is recommended that the gold-plated surface on the bottom be used as the reference surface for mounting the readhead. If the top of the readhead is used as the reference surface, the thickness tolerance of the readhead must be taken into account.

Ride height is the distance between the rubber on the ring and the sensor on the readhead. Tight ride height is recommended. Increasing the ride height exponentially increases encoder noise even when within installation tolerances.

The integrated LED can be used as an indicator. If the ride height is within the installation tolerances, the indicator LED will be green and will not change when the ring rotates. The center of the ring and the center of the readhead arc must be coaxial. The permissible eccentricity tolerances are given in the table below. Precise centering of the ring is essential, as the eccentricity of the ring mounting plays a major role in the overall accuracy.

Installation tolerances (readhead to ring)

Ride height $0.2 \pm 0.15 \text{ mm}$



Tangential displacement of the readhead $\pm 0.3 \text{ mm}$



Radial displacement of the readhead $\pm 0.4 \text{ mm}$



Non-parallel mounting Tilt angle $< 0.15^\circ$



Measuring ride height between the ring and the readhead

For a ready-to-use ride height (air gap) measurement, connect the encoder to a PC via the E201 interface and view the value directly using the RLS software. For more information refer to chapter [Accessories](#).

The signal level information read out via the communication interface can be used to calculate the ride height (distance between the rubber on the ring and the sensor on the readhead).

The value is proportional to the distance between the sensor and the ring. To calculate the real distance use the following formula:

$$\text{Ride height} = K \times \ln(\text{SignalLevel}) + N$$

Ln stands for natural logarithm.

The calculated ride height has a tolerance of $\pm 20 \mu\text{m}$.

K and N are depending on the encoder size and can be read from the register access.

Ring size	K	N
039	-83.56	865
053	-71.62	748

Installation tolerances (ring to shaft)

Recommended shaft tolerance is g6. See table of recommended tightening torques for RLS products (document TTD01) available at [RLS media center](#).

Self-calibration after installation

The self-calibration function eliminates the error caused by eccentricity, which is a dominant contributor to the accuracy of the encoder and is caused by the eccentric mounting of the ring. It cannot compensate for the magnetisation error between different rings. The Subdivisional Error (SDE) is negligible with AksIM. This function removes the error from one sine wave per revolution. The self-calibration function can be initiated by the user via selected communication interfaces or by using the appropriate USB encoder interface. Refer to the description of the selected communication interface for details. Self-calibration is not performed below 15 µm of eccentricity when custom desired angle is selected instead of full 360° rotation.

Requirements:

- Free mechanical rotation between 180° and 360° (the desired angle can be selected via the communication interface). The performance of the self-calibration procedure is optimal at 360° rotation and is reduced if the arc length is reduced.
- Good signal over the entire calibration angle.
- Maximum time available is 40 seconds.
- Variation of direction and speed are not important. Minimum speed depends on self-calibration timeout value. Default is 6 rpm.
- Suitable communication interface or adapter that enables the function to be triggered.

When the self-calibration process is complete, fast-flashing LED indicates whether the process was successful.

LED	Self-calibration status	
 Green flashing fast	Self-calibration successfully performed.	
 Orange flashing fast	Ring positioning is already perfect - correction was not performed.	
 Red flashing fast	Self-calibration not performed. Possible reasons:	
	• Eccentricity or radial offset is very high.	
	• Timeout. Ring is rotating too slowly (<6 rpm).	
	• Any error present during self-calibration procedure.	



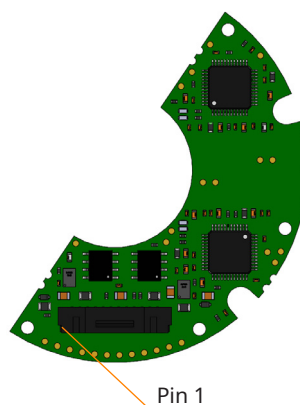
Explainer video: AksIM-4 self-calibration feature

Refer to the selected communication interface chapter for more details, as each interface supports different calibration capabilities.

Electrical connections

Pinout for connector option H: right-angle connector

	Connector	RS422 (BiSS)
Outer ring	1	V_{inA} (5 V)
	2	MA+
	3	MA-
	4	SLO+
	5	SLO-
	6	GND
Inner ring	7	GND
	8	SLO-
	9	SLO+
	10	MA-
	11	MA+
	12	V_{inB} (5 V)



Right-angle 12-pin low profile connector part number
5055671231

Counterpart mating connector part number
5055651201

	Connector	SPI EncoLink for Dual Encoder
Not connected	1	Not connected
	2	
	3	
	4	
	5	
	6	
Outer and inner ring	7	GND
	8	MOSI
	9	MISO
	10	NCS
	11	SCK
	12	V_{in} (5 V)

Pinout for connector option D: board-to-board connector

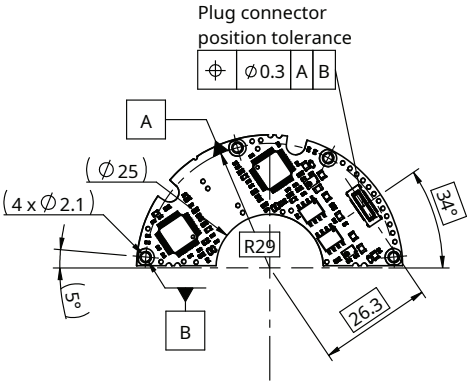
Board-to-board connector part number

DF40F(2.0)-30DP-0.4V

Counterpart / Customer mating connector options (part numbers):

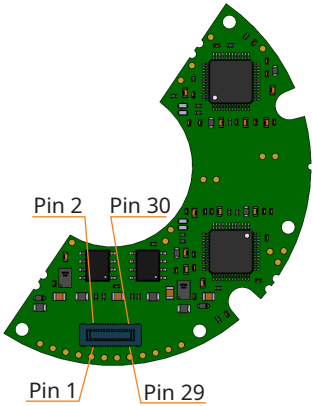
Receptacle/Plug	DF40F(2.0)-30DP-0.4V(##) Stacking Height / Distance between PCBs
DF40TC-30DS-0.4V(##)	3.5 mm
DF40TC(2.0)-30DS-0.4V(##)	4.0 mm
DF40TC(2.5)-30DS-0.4V(##)	4.5 mm
DF40TC(3.0)-30DS-0.4V(##)	5.0 mm
DF40TC(3.5)-30DS-0.4V(##)	5.5 mm
DF40TC(4.0)-30DS-0.4V(##)	6.0 mm

For the receptacle connector positioning, consult Hirose series DF40F data sheet.



Pinout

	Connector	RS422 (BiSS)
Outer ring	1	V _{inA} (5 V)
	2-4, 6, 8, 10, 12-18, 20, 22, 24, 26-28, 30	GND
	5	MA+
	7	MA-
	9	SLO+
Inner ring	11	SLO-
	29	V _{inB} (5 V)
	2-4, 6, 8, 10, 12-18, 20, 22, 24, 26-28, 30	GND
	25	MA+
	23	MA-
	21	SLO+
	19	SLO-

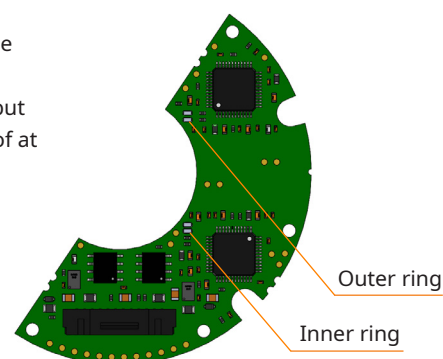


Readhead is ESD sensitive - handle with care.
Do not touch electronic circuit, wires or sensor area without proper ESD protection or outside of ESD controlled environment.

Status indicator LEDs

Two separate LED's are available, one for the inner ring and one for the outer ring. The LEDs provide visual feedback on signal strength, error status, and are used for setup and diagnostics. Flashing LED indicates that power is being supplied to the encoder, but communication has not been established. When communication is running at a rate of at least 5 readings per second, LED will be constantly lit.

For 6 line **SPI EncoLink for Dual Encoder** only: Since communication to the master is only possible through the inner ring encoder, the outer ring encoder does not use the main communication interface. As a result, the outer ring encoder LED only blinks to indicate current encoder status and that the power is supplied; it will never transition to a constantly lit state.



LED signal	Status
 Green	Normal operation; position data is valid.
 Orange	Warning; position is valid, but the resolution and/or accuracy might be out of specification. Some operating conditions are outside limits.
 Red	Error; position data is not valid.
 Slow flashing	Communication has not been established. Position was not requested within last 200 ms. Color of flashing - see above.
 No light	No power supply.
 Continuously fast flashing red	System error during start-up or operation.
 3 sec. fast flashing	Self-calibration result - see chapter <u>Self-calibration after installation.</u>

Multiturn counter

The multiturn option is selected with the resolution in the [Part numbering](#). The multiturn counter is 16 bits (0 to 65535 counts). Counting is only available when the encoder is powered, but the counter state is stored in a non-volatile memory at power-down and is restored at power-up. Maximum permissible rotation during power-down is $\pm 90^\circ$. If the rotation is greater than this, the encoder reports an error to indicate an invalid multiturn counter value. To reset this condition, it is necessary to apply a new multiturn counter value via the communication interface or cycle power to the encoder. If encoder is rotated for $\pm 360^\circ$ or for multiple rotations, this movement is not registered and no multiturn error is set. If any other error is set during a rotation of 90° or more, the multiturn counter value may become inconsistent with the mechanical position.

The user must implement the multiturn counter validation method by either:

- Activating the mechanical brake before the encoder goes into the power-down state and releasing the brake after the encoder is powered-up
- Presetting a new multiturn counter value each time the encoder is powered-up.
- Other user-implemented multiturn counter validation methods.

Multiturn - shaft turn counter limitations

Counter may have invalid value in following circumstances:

Possible reasons for failure	Solution
If encoder is rotated for $\pm 360^\circ$ or multiple rotations during off state.	Use mechanical brake.
If Error flag (red LED) is present for 90° rotation or more.	Read and evaluate Error bit.
When the encoder moves for 90° or more, or rotates 300 rpm or more when the encoder performs blocking operations (storing information in non-volatile memory, factory reset, write protect, self-calibration).	Stop rotation before performing these operations.
If user changes single-turn position offset for 90° or more.	Set new multiturn counter value right after setting zero position offset.
If any function for storing information to non-volatile memory (save configuration, factory reset, write protect, self-calibration) is active when power-down happens.	Keep power supply stable when performing those operations.

Multiturn error flag

Error flag is set in one of the following conditions:

- Detected movement of $>90^\circ$ and $<270^\circ$ when powered off.
- Detected speed of more than 300 rpm during blocking operation.
- High, unexpected positional difference detected (acceleration error).

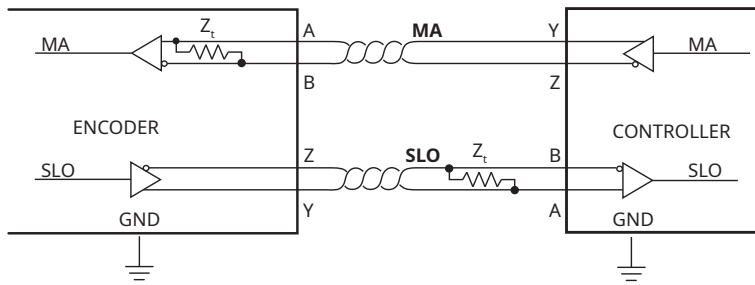
Multiturn error bit can be cleared by writing new value into the encoder or by power cycle.

BiSS C interface

Encoder position in natural binary code and encoder status are available via the BiSS C protocol. The position data is followed by two status bits (active low) followed by CRC (inverted).

BiSS is implemented for point-to-point operation, multiple slaves are not supported. Communication is bidirectional, the readhead is user programmable. Additional data can be read from the readhead.

Electrical connection

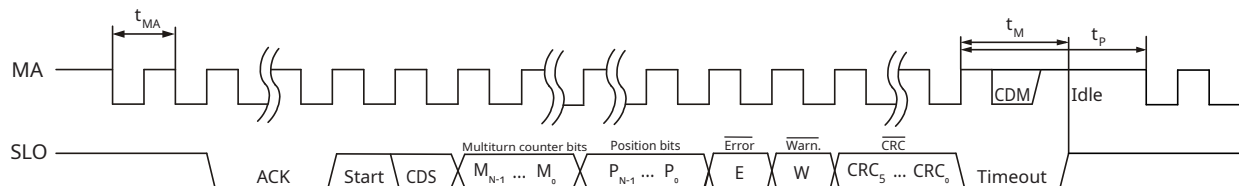


The signal MA is Master Clock with a maximum frequency of 5 MHz and SLO is Slave Out, whose data is transmitted on the rising edges on the line MA. The MA and SLO lines are 5 V RS422 compatible differential pairs. The RC termination on the MA line is built into the encoder. If the total cable length exceeds 5 m, termination on the controller is required. The nominal impedance of the cable should be 120 Ω .

Output protection

Excessive output current and power dissipation caused by faults or bus conflicts are prevented by two mechanisms. A foldback current limit at the output stage provides immediate protection against short circuits. In addition, a thermal shutdown circuit forces the driver outputs into a high-impedance state, if the chip temperature becomes too high.

BiSS C timing diagram



Data package description

Data	Length (N)	Description
$M_{N-1} - M_0$	16 bits	Multiturn counter value (length 0 when single turn option is selected)
$P_{N-1} - P_0$	19 bits	Absolute position inside one revolution
E	1 bit	Error status bit; inverted
W	1 bit	Warning status bit; inverted
$CRC_5 - CRC_0$	6 bits	Cyclic redundancy check; polynomial 0x43; inverted

Communication parameters

Parameter	Symbol	Min	Typ	Max
MA period	t_{MA}	200 ns		2.5 μ s
MA frequency	$f_{MA} = 1/t_{MA}$	400 kHz		5 MHz
ACK length	ACK		13 bits	
Transfer timeout	t_M		13 μ s	
Pause time	t_P	$t_M + 1 \mu$ s		
Latency				10 μ s
Mechanical bandwidth*				12.5 kHz
Mechanical sample rate				25 kHz
Maximum request rate				44 kHz (singleturn)

* AksIM samples at 25 kHz, so mechanical changes faster than 12.5 kHz cannot be detected at the output (Nyquist theorem). If the position request comes faster than the sampling frequency, the encoder recalculates the position at the time of the request based on the current ring velocity.

If number of clocks from master is less than specified, SLO within timeout is not necessarily in low state.

First valid frame is expected after encoder set-up time.

The request cycle starts with MA in idle state (MA is high). Its first falling edge initiates communication. The encoder responds by setting SLO to low on the second rising edge on the MA line and generating the ACK signal (Acknowledge). When the encoder is ready for the next request cycle, it indicates this to the master by setting SLO to high. The absolute position and the CRC data are available in binary format and are initially transmitted in MSB format.

Encoder data packet structure

For singleturn		
Bit	Status	Description
b26 : b8	Encoder position	MSB first (for 19 bit resolution)
b7	Error	If low, the position data is not valid.
b6	Warning	If low, the position data is valid, but some operating conditions are close to limits.
b5 : b0		Inverted CRC, calculated by using 0x43 polynomial

When error is active (error bit is low) singleturn position data (b26 : b8) is replaced (b23 : b8) by detailed status bits (see table on next page). Detailed status bits are right aligned, so that b0 of the status matches b8 of the encoder data packet. When the warning bit is active, the position data remains valid.

For multiturn		
Bit	Status	Description
b42 : b27	Multiturn counter	
b26 : b8	Encoder position	MSB first (for 19 bit resolution)
b7	Error	If low, the position data is not valid.
b6	Warning	If low, the position data is valid, but some operating conditions are close to limits.
b5 : b0		Inverted CRC, calculated by using 0x43 polynomial

Detailed status		
Bit	Status	Description
b15	Reserved	
b14	Warning	Temperature out of range. The readhead temperature is out of specified range (T_{min} , T_{max}).
b13	Warning	Signal amplitude low. The distance between the readhead and the ring is too large.
b12	Warning	Signal amplitude high. The readhead is too close to the ring.
b11	Warning	Signal decoding below certain threshold - position decoding might be inaccurate or fail.
b10	Warning	Overspeed. Ring rotation speed is too high.
b9	Error	Multiturn counter error (value always 0 when singleturn option is selected)
b8	Error	Acceleration error. The position data changed unexpectedly. A stray magnetic field is present or metal particles are present between the readhead and the ring.
b7	Error	Magnetic pattern error. A stray magnetic field is present or metal particles are present between the readhead and the ring or radial positioning between the readhead and the ring is out of tolerances.
b6	Error	Signal lost. The readhead is out of alignment with the ring or the ring is damaged.
b5	Error	Signal amplitude too high. External magnetic field is present.
b4	Error	System error. Malfunction inside the circuitry. To reset the System error bit try to cycle the power supply while the rise time is shorter than 20 ms.
b3	Error	Internal power supply error
b2	Error	System error. Inconsistent calibration data is detected. To reset the System error bit try to cycle the power supply while the rise time is shorter than 20 ms.
b1	Reserved	
b0	Reserved	

Encoder programming

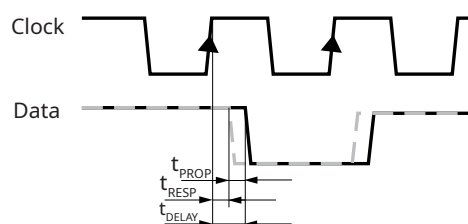
For certain communications encoder supports register access which allows setting zero position, running self-calibration function, configuring the encoder, reading signal level indicator, temperature and detailed status bits. For more information [contact RLS](#).

Cable length compensation

The readhead needs 60 ns to respond to incoming clocks (t_{RESP}). The change on the Data signal is delayed by 60 ns after the rising edge on the Clock line. An additional delay is caused by the time the signal takes to propagate through the cable to the readhead and back (t_{PROP}). This delay is typically 14 ns per 1 meter cable. The total cable length from the encoder to the receiver must be considered.

The total delay (t_{DELAY}) is calculated as in the formula below.

A proper implementation of BiSS Master should automatically measure t_{DELAY} and adjust the internal timing to compensate for it. BiSS Master without compensation for cable delay will work even with short wiring (up to 1 meter at 5 MHz clock frequency).



$$t_{DELAY} = t_{RESP} + t_{PROP} \times \text{cable length}$$

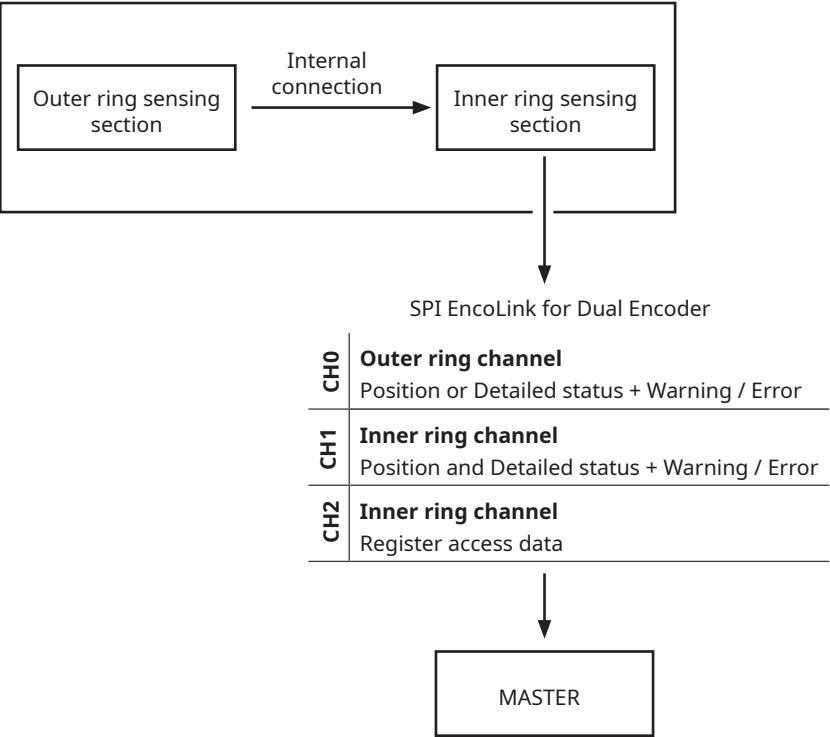
SPI EncoLink for Dual Encoder

This chapter is a supplement to the SPI EncoLink Interface and describes only the features and specifics of the dual encoder version. For a complete description of the interface, refer to the [SPI EncoLink Interface](#) chapter.

The SPI EncoLink for Dual Encoder enables transmission of dual-encoder data over a 6-wire interface, eliminating the need for two separate encoder interfaces (typically 12 wires) and reducing cabling and overall system complexity. Data from both encoder sections is transmitted across three channels.

- Channel 0: Position and general status data of the outer ring (position data is replaced by detailed status when the general error bit is active)
- Channel 1: Position, detailed and general status data of the inner ring (position data is replaced by detailed status when the general error bit is active)
- Channel 2: Register access for the inner ring section

The shared 6-wire interface provides a compact and efficient solution for dual-encoder applications, while maintaining full access to position and status data.



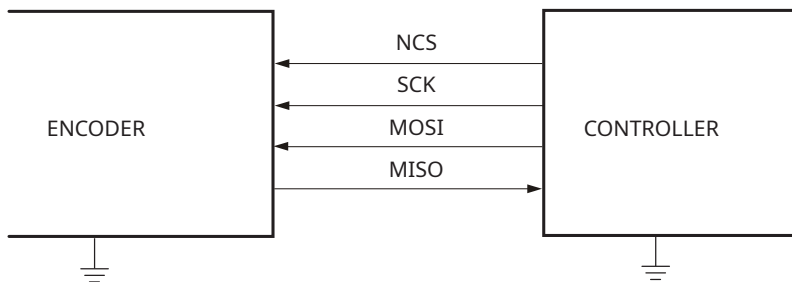
SPI EncoLink interface

The Serial Peripheral Interface (SPI) bus is a four-wire bidirectional synchronous serial communication interface, typically used for short distance communication. It operates in full duplex mode, where master (controller) selects the slave with NCS line, generates clock signal on SCK line, sends command over MOSI line and receives data over MISO line.

All data signals are 3.3 V LVTTTL. Inputs are 5 V tolerant. The maximum current sourced or sunk from signal lines should not exceed 5 mA. Single-ended signals should be as short as possible, especially when high frequencies are used.

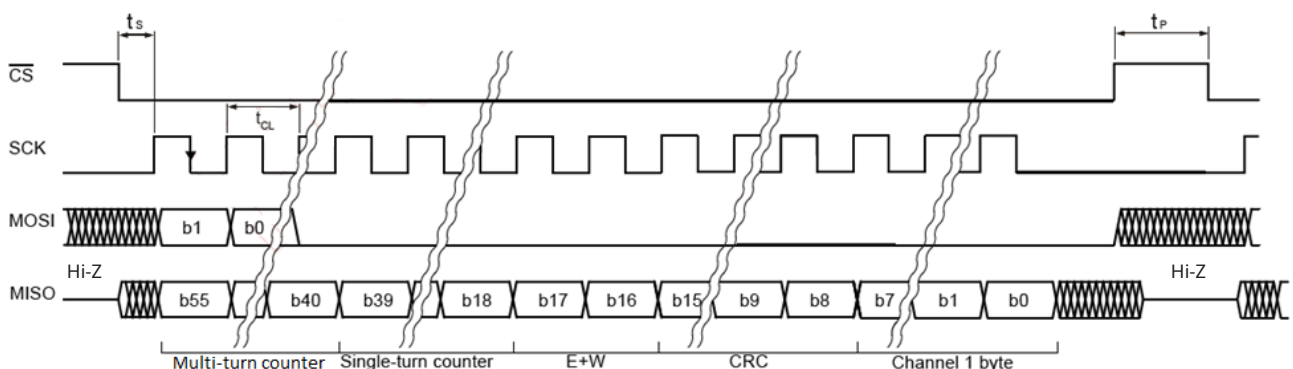
Signal termination: 100 Ω resistors are added in series with all SPI signals.

Electrical connection



Signal	Description
NCS	Active low. NCS line is used for synchronisation between master and slave devices. During communication it must be held low. Idle is high. When NCS is high, MISO line is in high-Z mode. This allows connection of multiple slaves in parallel, sharing all lines except NCS.
SCK	Serial clock. Shifts out the data on rising edge. Data is stable and valid on falling edge.
MOSI	Master output $\rightarrow$ Slave input. Command from the controller to encoder.
MISO	Master input $\leftarrow$ Slave output. Data is output on rising edge on SCK after NCS low. When NCS is high, MISO line is in high-Z mode.

SPI timing diagram



The controller starts the communication by setting the NCS signal low. A delay of t_s is required to allow the encoder to prepare the data which is then shifted to MISO output on rising edges of clock signal SCK.

Encoder Position and General Status (active low) data is transmitted, followed by CRC (inverted) of the entire data packet.

Communication parameters

Parameter	Symbol	Min	Typ	Max
NCS to SCK delay	t_s	2 μ s		
Clock frequency	f_{SCK}			6 MHz*
Pause time (NCS high)	t_p	2 μ s		
Sampling rate				50 kHz
Latency				10 μ s
SPI settings	CPOL= 0 (clock idle is low)			
	CPHA = 1 (data is output on clock rising edge and sampled on clock falling edge)			

* With 500 mm cable or less.

SPI data structure

Data sent by the master on the MOSI line (b15:b0):

Byte	B1	B2
Bits	b15..b8	b7..b0
Data length	8 bits	8 bits
Contents	Command 0x00*	Data

Command and Data values should be always 0x00 if EncoLink register access is not in use.

* Special commands:

0xAA Reset EncoLink channels

0xBB Request Version information from encoder

Command 0x00 (Singleturn variant of the encoder)

Data received over the MISO line contain:

Bytes	Bits	Data length	Contents
B1, B2, B3	b39..b18	Singleturn resolution*	Encoder position / Detailed status (If b17 (General Error) is 0 (active) then position data is replaced by Detailed status.)
	b17	1 bit	Error (active low)
	b16	1 bit	Warning (active low)
B4	b15..b8	8 bits	CRC (inverted)
B5	b7..b0	8 bits	EncoLink register access (If EncoLink register access is not used, the last byte can be ignored and the SPI transaction ended after B4.)

* Encoder position is binary, left aligned, MSB first. Remaining bits are set to zero

Command 0x00 (Multiturn variant of the encoder)

Data received over the MISO line contain:

Bytes	Bits	Data length	Contents
B1, B2	b55..b40	16 bits	Multiturn
B3, B4, B5	b39..b18	Singleturn resolution*	Encoder position / Detailed status (If b17 (General Error) is 0 (active) then position data is replaced by Detailed status.)
	b17	1 bit	Error (active low)
	b16	1 bit	Warning (active low)
B6	b15..b8	8 bits	CRC (inverted)
B7	b7..b0	8 bits	EncoLink register access (If EncoLink register access is not used, the last byte can be ignored and the SPI transaction ended after B6.)

* Encoder position is binary, left aligned, MSB first. Remaining bits are set to zero

On the SPI EncoLink interface, the multiturn counter of the outer ring channel (CH0) cannot be reset. The multiturn count reported in the CH0 position frame may hold a non-zero value at first power-up. See diagram on [page 18](#).

General status (next to Encoder position)

Bit	Status	Description
b17	Error	If bit is reset, position is not valid. Red LED.
b16	Warning	If bit is reset, encoder is near operation limits. Position is valid. Resolution and/or accuracy might be lower than specified. Orange LED.

Detailed status

Bit	Status	Description
b15	Reserved	
b14	Warning	Temperature out of range. The readhead temperature is out of specified range (T_{min} , T_{max}).
b13	Warning	Signal amplitude low. The distance between the readhead and the ring is too large.
b12	Warning	Signal amplitude high. The readhead is too close to the ring.
b11	Warning	Signal decoding below certain threshold - position decoding might be inaccurate or fail.
b10	Warning	Overspeed. Ring rotation speed is too high.
b9	Error	Multiturn counter error (value always 0 when singleturn option is selected)
b8	Error	Acceleration error. The position data changed unexpectedly. A stray magnetic field is present or metal particles are present between the readhead and the ring.
b7	Error	Magnetic pattern error. A stray magnetic field is present or metal particles are present between the readhead and the ring or radial positioning between the readhead and the ring is out of tolerances.
b6	Error	Signal lost. The readhead is out of alignment with the ring or the ring is damaged.
b5	Error	Signal amplitude too high. External magnetic field is present.
b4	Error	System error. Malfunction inside the circuitry. To reset the System error bit try to cycle the power supply while the rise time is shorter than 20 ms.
b3	Error	Internal power supply error
b2	Error	System error. Inconsistent calibration data is detected. To reset the System error bit try to cycle the power supply while the rise time is shorter than 20 ms.
b1	Reserved	
b0	Reserved	

Error behavior and internal encoder speed measurement

Each time the Error bit is reset, the internal speed is invalidated and is set to 0.

Three consecutive encoder cycles after the error condition has been cleared (Error bit set), the calculated speed is valid again.

CRC check

Length: 8 bits

Polynomial: 0x97

Value is inverted.

CRC calculation example is in application note document CRCD01, available for download at [RLS media center](#).

Command 0xBB (Encoder identification request)

Request Version information from encoder: Encoder returns 19 bytes, presented in the table below.

Byte	Description	Value
B1	Protocol version	4 = Encolink v4
B2	Number of bytes in communication frame	5/7 bytes in communication frame (see command 0x00)
B3..B18	Part number	See chapter Part numbering
B19	CRC	Inverted

EncoLink Register access

Encoder supports running self-calibration function, reading signal level value, temperature, detailed status bits, identification information and other diagnostic values. Additional functions are available with use of EncoLink libraries. [Contact RLS](#) for details. To access EncoLink registers it is recommended to use EncoLink library provided by RLS.

The self-calibration function and the description of the other registers can be found in document APP04, available for download at [RLS media center](#).

Register access, self-calibration, and multi-turn (MT) settings are supported only on inner ring interface versions.

Make sure that you only execute commands that store parameters in non-volatile memory if the ambient temperature is below 105 °C.

Persistent detailed status

The EncoLink register 0x000A accumulates all status bits that were active during encoder operation in each internal encoder cycle, even if communication is not active. The format of the data is the same as standard Detailed status register.

Clearing the Persistent status register is performed by writing value 0x62 into Command register 0x00BD.

Part numbering

Readhead

	MD	053C	BB	EE	R	A	D	P	00
Series									
MD - Dual AksIM-4 board-level readhead									
MRA ring compatibility									
053C - For use with MRA053 and MRA039 rings									
Communication protocol combination									
BB - Outer ring (size 053): BiSS C, RS422 and inner ring (size 039): BiSS C, RS422									
NF - Outer and inner ring position data via 6 wire SPI Encolink									
Resolution combination									
EE - Outer ring (size 053): 19 bits per revolution, Inner ring (size 039): 19 bits per revolution									
RR - Outer ring (size 053): 19 bits per revolution + 16 bits multiturn counter, inner ring (size 039): 19 bits per revolution + 16 bits multiturn counter									
Option									
R - Standard									
Dual type and connector orientation									
A - Concentric dual, axial or board-to-board connector exit									
C - Concentric dual, radial connector exit									
Connector option									
D - Small, floating, board-to-board									
H - Molex Micro-Lock, 12 pin, 1.25 mm pitch									
Option									
P - High pressure/vacuum and temperature range -40 °C to +105 °C									
Special requirements									
00 - No special requirements (standard)									

For more dimensions and configurations please **contact RLS**.

Table of available combinations

Series	Ring compatibility	Communication protocol	Resolution combination	Option	Dual type and connector orientation	Connector option	Option	Special requirements
MD	053C	BB	EE / RR	R	A	D	P	00
					C	H		
		NF	EE		C	H		

Magnetic ring

	MRA	053	P	G	040	D	S	N	00
Series									
MRA - AksIM magnetic ring									
Outer diameter and readhead compatibility									
039 - 39 mm									
053 - 53 mm									
Thickness									
N - 1.6 mm									
P - 2.8 mm									
Installation type									
C - Countersunk holes type A (use flat-head fasteners DIN 965 / 7046)									
G - Glue									
Inner diameter									
020 - 20 mm									
040 - 40 mm									
Magnetization type									
D - Standard for stamped rings									
Material									
S - Stamped metal plate with CPE rubber									
Zero marking									
H - Hole									
N - None									
Special requirements									
00 - No special requirements (standard)									

For more dimensions and configurations please **contact RLS.**

Ring part number combinations

MRA053PG040DSN00
MRA039NC020DSH00

Accessories



Cable assembly, 0.5 m
ACC101

See chapter [Cable assemblies](#).



Cable assembly, 1 m
ACC102

See chapter [Cable assemblies](#).



USB interface

E201-9B (for BiSS C communication interface)

E201-9P (for SPI EncoLink communication interface)



Magnet viewer
MM0001



Shims for height adjustment

MD053CCACC001 (for the readhead)

MRA039CACC001 (for the MRA039 ring)

Packaging

There are two packaging options. Less than 20 products are packed individually in an antistatic box. If more than 20 systems are ordered, the parts are packed in antistatic plastic trays. Magnetic rings and readheads are packed separately.

Bulk packaging:

Readheads		
Part	Tray size	Box size
MD053C	NA	1 tray per box

Magnetic rings		
Part	Tray size	Box size
MRA039	10 units per tray	15 trays per box
MRA053	10 units per tray	15 trays per box

Cable assemblies

Cable specifications

Part numbers	ACC101 (cable length: 0.5 m)	ACC102 (cable length: 1 m)
Compatible readhead	Readhead with connector option "H"	Readhead with connector option "H"
Cable type	PUR outer sheath, tinned copper braided shield individual conductor: FEP insulation, tinned copper 7 strands	PUR outer sheath, tinned copper braided shield individual conductor: FEP insulation, tinned copper 7 strands
Connector 1	Molex Micro-Lock 5055651201	Molex Micro-Lock 5055651201
Connector 2	2 × DSUB-9 M	Flying leads
Wire diameter	2 × 3.6 mm	2 × 3.6 mm
Configuration	6 × AWG 28/7, tinned copper	6 × AWG 28/7, tinned copper
Rated voltage	Core/Core 600V	Core/Core 600V
Operating temperature	-40 °C to +105 °C	-40 °C to +105 °C

Connector 1		Connector 2				
Pin number		Pin number	Wire colour	BiSS C	SPI EncoLink	
		Connector 2-A (Outer ring)	1	Shield	/	Shield
			4	/	/	/
			8	/	/	/
Connector 1	1		5	Brown	V _{inA} (5V)	/
	2		2	Pink	MA+	/
	3		3	Grey	MA-	/
	4		6	Green	SLO+	/
	5		7	Yellow	SLO-	/
	6		9	White	GND	/
	7	Connector 2-B (Inner ring)	9	White	GND	GND
	8		7	Yellow	SLO-	MOSI
	9		6	Green	SLO+	MISO
	10		3	Grey	MA-	NCS
	11		2	Pink	MA+	SCK
	12		5	Brown	V _{inB} (5V)	V _{inB} (5V)
			8	/	/	/
			4	/	/	/
			1	Shield	/	Shield

ACC101 can be used for direct connection to E201-9B USB encoder interface.

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Document issues

Issue	Date	Page	Description
1	12. 10. 2026	-	New document

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